Sacramento Municipal Utility District
Solar Domestic Hot Water Heating
Profile #66

Executive Summary

Sacramento Municipal Utility District (SMUD) is rapidly building an impressive reputation as a utility that is aggressively pursuing energy efficiency and renewable energy. In fact, largely due to the early retirement of the Rancho Seco nuclear power plant, SMUD is facing severe capacity constraints and has developed plans to secure 800 MW from its demand-side management programs and 400 MW from renewable sources.

Given these ambitious resource goals, it should be no surprise that the utility has devoted considerable attention to solar programs. On the supply-side, SMUD operates the largest photovoltaic generating plant in North America, a 2 MW plant located in the shadow of "the Ranch." Recently the utility has begun to install residential-scale PV units on the roofs its customers. These participants are volunteering to be part of SMUD's innovative attempt to build a decentralized power plant. Finally, 150 MW of solar thermal generation is on the drawing board.

To conserve its use of traditional energy resources, SMUD implemented the most aggressive solar domestic hot water heating system program in the country in 1992 and plans to install 20,000 systems by the year 2000, resulting in annual energy savings of 48,300 MWh and a summer peak demand reduction of 7.4 MW. This magnitude of market penetration represents fully half of the residential electric water heating market in Sacramento and nearly a quarter of the total electric water heating market for all sectors, a radical increase when compared to the fewer than ten systems installed each year in Sacramento prior to the launch of SMUD's program!

Fully 875 solar systems were installed in the program's first year, providing 400 kW of summer peak capacity and total annual energy savings of 2,775 MWh. By October of 1993, an additional 600 systems were in operation, resulting in a further demand reduction of 240 kW and additional energy savings of 1,757 MWh.

The program cost SMUD $1,150,000 during 1992. This translates into a utility cost of $1,314 per water heater and preliminary assessments show that the utility's average system costs for 1993 have dropped to $976 per system. An incentive cap instituted by SMUD in late 1993 will likely improve the cost-effectiveness of the program, and long-term costs will decrease as the market for SDHW systems becomes more established, thereby reducing unit production and installation costs.

Solar Domestic Hot Water Heating

Utility:	Sacramento Municipal Utility District
Sector:	Residential
Measures:	SRCC OG-300 certified solar domestic hot water heating systems
Mechanism:	Rebates to cover portion of system costs; low-interest loans to cover the remainder; delivered in close cooperation with solar industry
History:	Piloted May, 1992; expanded in the fall of 1992

1992 Program Data

Energy savings:	2,775 MWh
Lifecycle energy savings:	27,750 MWh
Summer capacity savings:	0.4 MW
Cost:	$1,150,000

Cumulative Data (1992 - Present)

Energy savings:	7,307 MWh
Lifecycle energy savings:	45,318 MWh
Summer capacity savings:	0.64 MW
Cost:	$1,735,600

Conventions

For the entire 1993 profile series all dollar values have been adjusted to 1990 U.S. dollar levels unless otherwise specified. Inflation and exchange rates were derived from the U.S. Department of Labor's Consumer Price Index and the U.S. Federal Reserve's foreign exchange rates.

The Results Center uses three conventions for presenting program savings. **Annual saving**s refer to the annualized value of increments of energy and capacity installed in a given year, or what might be best described as the first full-year effect of the measures installed in a given year. **Cumulative savings** represent the savings in a given year for all measures installed to date. **Lifecycle savings** are calculated by multiplying the annual savings by the assumed average measure lifetime. **Caution:** cumulative and lifecycle savings are theoretical values that usually represent only the technical measure lifetimes and are not adjusted for attrition unless specifically stated.

Sacramento Municipal Utility District (SMUD or the District) is a municipally-owned utility that was established in 1923. The service territory encompasses 900 square miles within and around the City of Sacramento, the capital of California. It is the fifth largest public utility in the nation serving 468,671 customers and selling 8,471 GWh to those customers in 1992. In 1992, the District had 2,373 full-time employees.[R#1]

The District is currently governed by a five-member Board of Directors elected for four-year terms, however, the Board will be expanded to seven members beginning in 1994. The Board of Directors makes policy decisions for the District and appoints the General Manager who is responsible for the utility's operations.[R#1]

In 1992, SMUD's electricity generation was primarily comprised of purchases, at 8,228 GWh, or 86.3% of the total power supply. The closure of SMUD's Rancho Seco nuclear power plant in 1990 that had supplied 2,812 GWh in 1988 and 1,439 GWh in 1989 forced the utility to increase the use of purchased power. The remainder of SMUD's power in 1992 came from hydroelectric sources (8.5%), geothermal resources (5%), gas turbines (<1%), and photovoltaics (<1%).[R#1]

The peak demand for 1992 was 2,119 MW and occurred in August. The utility uses a number of diverse resources to meet this peak. As noted above, purchased power comprises the bulk of the District's capacity (1,311 MW). However, SMUD has substantial hydro (659.4 MW) and geothermal (183 MW) generating capacity, as well as 2 MW of photovoltaic generating power outside of the closed Rancho Seco facility.[R#1,12]

SMUD's resource plan through the year 2000 is designed to substantially reduce the need for purchased power through emphasis on energy efficiency and renewable energy. By the end of the decade the District plans to gain about 800 MW of capacity from its DSM programs, approximately equal to SMUD's projected growth. On the supply side, the utility plans to add 700-800 MW of gas-fired cogeneration in the next five years. These projects will be pursued in cooperation with existing and new local industries and will utilize some of the most efficient gas-fired turbine systems available.

SMUD 1992 STATISTICS

Number of Customers	468,671	
Energy Sales	8,741	GWh
Energy Sales Revenue	$615.8	million
Peak Demand	2,119	MW
Generating Capacity	844	MW
Purchased Power	1,311	MW
Reserve Margin	1.7	%
Average Electric Rates		
Residential	7.61	¢/kWh
Commercial, Industrial & Other	7.01	¢/kWh

In addition to these cogeneration systems SMUD plans to incorporate a variety of renewable supply options. The initial plan calls for the installation of 150 MW of solar thermal, 50 MW of wind, and an additional 200 MW drawn from a combination of photovoltaic, biomass, fuel cell, and geothermal sources, for a total of 400 MW of additional renewable energy.[R#2] By the year 2000 this integrated resource plan will eliminate the need for any additional purchased power.

By following this plan of action SMUD is moving away from its dependence on purchased power in the direction of energy sustainability. Many scenarios for a sustainable energy future are based on the use of renewable resources to supply energy, efficiency measures to control demand, and the use of natural gas as a "transition fuel" to provide energy until the renewable resources are available.[R#5] From a societal perspective SMUD's apparent progress in the direction of sustainability is commendable and the leadership of the utility deserves credit for pursuing this path. ■

Utility DSM Overview

Sacramento Municipal Utility District began its energy efficiency efforts in 1976 with the creation of a Conservation Department. Initially this department focused on customer education and basic residential efficiency measures such as attic insulation retrofits, rebates for energy-efficient construction, and a test of direct load control for air conditioners. These efforts were expanded in the early 1980s, in part as a response to state and federal mandates such as the California Energy Commission's (CEC) "Load Management Standards" and the U.S. Department of Energy's (DOE) "Residential Conservation Service" program.[R#3]

SMUD DSM PROGRAMS

Residential Retrofits

- Audit
- Lighting
- Space Heating
- Space Cooling
- **Solar Domestic Hot Water Heating**
- Refrigerators

Commercial & Industrial Retrofits

- Audit
- Lighting
- Refrigeration
- Dishwashing
- Energy Management Systems
- Motors
- Process Improvements
- Daylighting
- Heating & Cooling Equipment

Residential New Construction

- Advantage Home

Commercial & Industrial New Construction

- Advantage Building

Dispatchable Load Management

- Peak Corps
- C&I Interruptable
- Agricultural Water Heater Pump

Non-Dispatchable Load Management

- Pool & Spa Pumps

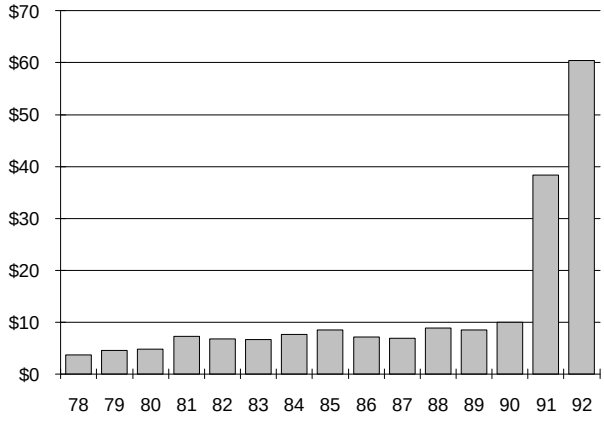
DSM Overview	*Annual DSM Expenditure (x1000)*	*Annual Energy Savings (GWh)*	*Annual Summer Capacity Savings (MW)*
1978	$3,608	negligible	14
1979	$4,501	"	2
1980	$4,758	"	2
1981	$7,189	"	4
1982	$6,772	"	7
1983	$6,561	"	7
1984	$7,548	"	9
1985	$8,503	"	19
1986	$7,155	"	13
1987	$6,903	"	19
1988	$8,839	"	25
1989	$8,432	"	11
1990	$10,000	9.0	85
1991	$38,317	51.0	56
1992	$60,390	110.0	50
Total	$189,477	170.0	323

The utility increased its conservation and efficiency efforts on its own initiative during the 1980s. Participation in the residential air conditioner cycling program was dramatically increased and the residential program was expanded to include more measures to induce larger participation and increase savings.[R#3]

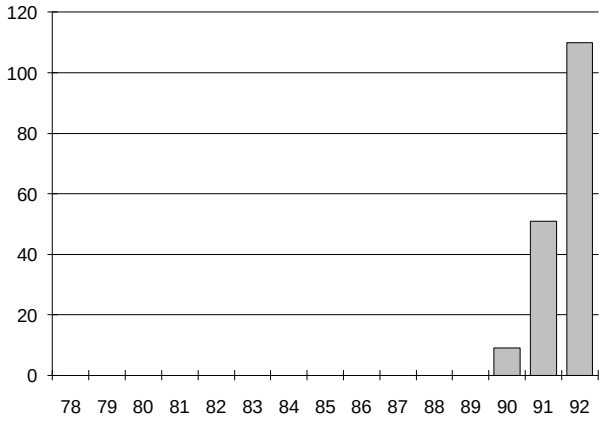
In response to significant needle peaks resulting from air conditioning load, SMUD developed and adopted the "Load Management Business Plan" in 1987. Implementation of this plan improved the utility's load management programs with a continued focus on residential air conditioning units and new attention to commercial and industrial curtailable efforts, thermal energy storage incentives, and time of use rates.[R#3]

The utility entered a new and aggressive phase of conservation efforts in 1990 as a result of the closure of the Rancho Seco nuclear power plant and a changing corporate vision of the utility's role as a provider of energy. Since 1990 SMUD's expenditures on DSM have reflected its

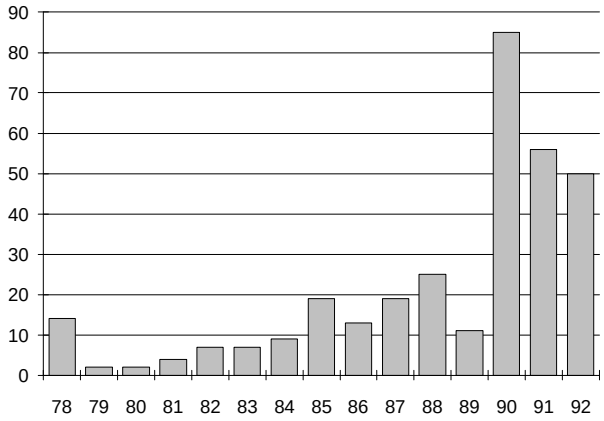
ANNUAL DSM EXPENDITURE (x 1,000,000)



ANNUAL ENERGY SAVINGS (GWH)



ANNUAL CAPACITY SAVINGS (MW)



aggressive portfolio of programs. While the industry-wide average for DSM spending as a percentage of gross revenue was only 0.7 percent in 1990 [R#4], SMUD's 1992 expenditures were 6.5 percent, the largest in the United States.[R#1]

To help meet the projected shortfall resulting from the loss of Rancho Seco, SMUD developed an energy efficiency goal, what it calls its "Conservation Power Plant," of 800 MW by 2000. Savings were identified in three major areas: Energy Efficiency Retrofit, New Construction, and Load Management, and the utility began design and implementation of various programs in these areas. The attached list contains SMUD's current programs in each area. Additionally, the utility has a tree-planting initiative, a school program, and a resource bidding pilot.

One of the most intriguing current programs is the Solar Domestic Hot Water (SDHW) program, the subject of this profile. Sacramento Municipal Utility District calculated that SDHW systems could provide substantial energy and capacity benefits to the utility by replacing existing electric water heating. The utility decided to design and implement a program that would capture these energy benefits while lowering the costs of systems and improving the SDHW market.

Most of the utility's programs target both capacity and energy savings, with the obvious exception of the load management programs. This focus is in direct contrast with SMUD's efforts prior to 1990 that were almost exclusively capacity oriented. As the attached charts show, energy savings from DSM efforts are negligible until 1990. However, the current batch of programs are providing substantial energy and capacity savings: a total of 113 GWh in 1992, and total available demand reduction of 294 MW by the end of 1992.[R#6]

SMUD continues to refine its DSM activities. The utility underwent a review by the Natural Resources Defense Council and the Conservation Law Foundation during 1992. This review resulted in recommendations that SMUD has adopted to refine the cost-effectiveness screen to account for the benefits of reducing peak demand, to implement direct-installation programs for residential customers to improve participation, to encourage retrofit at time of replacement, and to expand and intensify evaluation efforts.[R#6] ■

Program Overview

The District began a program for residential solar domestic hot water heating (SDHW) in 1992 as a result of the technical potential identified in its service territory for reducing electric use from water heating. The utility became interested in SDHW as both an energy saving and peak shaving opportunity. The program is also designed to drive down the first cost of SDHW systems, identified as the primary barrier to adoption of this measure, to the point where solar is cost competitive with other water heating measures. The utility plans to have over 20,000 systems in use by 2000, equivalent to roughly 50 percent of the residential electric water heating market and roughly 25 percent of the total market for electric water heating in Sacramento.[R#3,7] This level of participation is estimated to result in energy and capacity savings of 48,300 MWh per year and 7.4 MW by 2000.[R#7]

In the last six months of 1992 the program targeted the installation of 800 systems and SMUD was able to complete 875 systems. These installations are estimated by SMUD to have saved 2,775 MWh and 400 kW in 1992.[R#7]

The program has undergone some changes in design and implementation strategies. It was initially a contractor-driven effort, where SMUD worked closely with the local SDHW contractors who sold the systems. The utility modified this design in 1993, opting to bulk-purchase a number of systems for resale to further drive down first costs that were still noted as the chief barrier to participation. SMUD believed that this path would allow costs to be substantially decreased, primarily through a reduction in marketing expenses. However, the utility realized that it was unable to meet installation targets under the bulk purchase program and that the burden of not meeting this target outweighed the benefits associated with bulk purchase of the systems.

Thus the utility phased out the bulk purchase component of the program, and returned to a contractor-driven program in September of 1993. This program is driven by performance-based rebates and financing for SDHW systems based on the Solar Savings Ratio (SSR) of the system. (The SSR is the percentage of energy saved by the solar system as compared to a standard water heater and is determined by calculating the percentage of hot water service the solar system is able to provide). SMUD has also incorporated a cap on the amount of financing to discourage inflationary pricing.[R#7]

SMUD intends to install 900 systems during 1993, of which 800 will be in residential, single family homes. The remaining systems will be placed in commercial and multi-family buildings, expanding the scope of the program to target the remainder of the water heating market. In 1994, the goal is 1,800 units, including 1,500 residential single family systems.[R#7]

SMUD is also working to expand the use of SDHW systems by participating in the USH2O project. USH2O is a national collaborative effort of utilities and solar manufacturers supported by the U.S. Department of Energy attempting to improve the cost-effectiveness of SDHW systems by increasing the number of systems installed in the market. The collaborative is working on a number of issues related to SDHW systems including cost-effectiveness and field performance evaluation, DSM program design and implementation, standards and specifications and assisting stakeholders to remove other barriers to the widespread use of SDHW systems.

SMUD anticipates significant benefits from its participation in USH2O, particularly through an increase in the number of utilities offering DSM programs for this technology. More DSM should translate to an increased manufacturing capability and a unit price reduction for SDHW systems, in turn reducing the costs of SMUD's program.

Several other utilities have DSM programs for solar domestic water heating. Utilities that currently offer incentives for SDHW systems include the Eugene Water & Electric Board, the City of Santa Clara, and Tucson Electric Power Company. Several utilities are in the program development stage, including Central Vermont Public Service Corporation, the City of Lake Worth, Florida, the City of Tallahassee, Hawaiian Electric Company, New England Electric System, Potomac Electric Power Company, Sierra Pacific Power, and Wisconsin Public Service Corporation.[R#8] ■

SOLAR DOMESTIC HOT WATER HEATING

THE OPPORTUNITY

There are significant savings to be gained from improved water heating efficiency as residential water heating accounts for roughly 5.8 percent of total U.S. energy consumption. However, solar domestic water heating systems accounted for only one percent of the U.S. water heating market in 1990, with 95 percent of the SDHW market in the residential sector.[R#8] SDHW systems have the potential to reduce annual energy consumption for this end-use by roughly 60 to 70 percent, and can also cut the contribution of electric water heaters to the utility peak demand by approximately 25 percent in the winter and eliminate it in the summer.[R#7,8,13] This summer peak reduction amounts to approximately 400 watts for each SDHW system installed.[R#13]

A BRIEF HISTORY

SDHW systems became very popular during the 1970s and early 1980s as the result of a 40 percent Federal tax credit for their installation coupled with some state-specific tax credits. The SDHW industry expanded extremely rapidly resulting in an over-extension of production and distribution capability and a glut of products and installations of dubious quality. With the end of the tax credits the industry sharply contracted, leaving many systems in place without proper technical support for their users. This created a serious credibility problem for the remaining industry and reliability questions for the technology due to the inferior design, manufacturing, and installation of some systems.

The technology that remains available today, however, has become much more reliable as the result of natural competition among the remaining industry and the advent of standards, most recently the Solar Rating and Certification Corporation (SRCC) Standard OG-300. SRCC, an independent, non-profit organization, was formed in 1980 by solar manufacturers, the solar industry trade association, and the Interstate Solar Coordination Council to address reliability and perception problems by providing accurate and credible information. The industry has enjoyed slow but steady growth since 1988 due to the improved reliability of SDHW systems, but the technology remains under-utilized as a result of the lingering perceptions from the tax credit era and the high first cost of SDHW relative to other water heating options.

THE TECHNOLOGY

SDHW systems are classified as either active or passive. Active systems use a pump powered by another fuel source to circulate fluid through the system. Passive systems have no pump. Because SDHW systems provide between 30 to 80 percent of typical residential hot water requirements, all systems have some form of backup power and either electricity or natural gas can be utilized depending on the existing fuel source. ☞

SOLAR DOMESTIC HOT WATER HEATING (CONTINUED)

These systems are also categorized as either open or closed-loop. Closed-loop systems circulate a fluid other than water in the collector and then heat the water via a heat exchanger. In contrast, open-loop systems heat the water in the system directly.

There are several commercially-available models of SDHW systems in use today. These are briefly described below.[R#8]

Batch: A batch system is an open-loop, passive system consisting of one or more water heater tanks placed in an insulated box and located in direct sun.

Thermosiphon: Also a passive system, but can be either open or closed-loop. A solar collector is placed below the water storage tank, allowing the heated water to rise to the tank by natural convection while cool water sinks to the collector (thermo-siphoning). This system faces two serious constraints. First, the tank must be above the collector, and therefore may require reinforced attics or roofing. Second, the system is vulnerable to failure when the temperature falls below freezing.

Recirculation or Bleed: An open-loop, active system with the ability to circulate hot water from the storage tank through the collector to protect against freezing. However, pumping heated water back to the collector is inefficient, so bleed systems are generally in use only in warmer climates.

Draindown: An open-loop, active system that pumps water from the storage tank to the collector and back. An electrically-powered draindown valve protects the system from freezing by cutting off circulation to exposed plumbing when the temperature drops into the low 40s F.

Drainback: A closed-loop, active system utilizing two storage tanks: one to store hot fluid from the collector and a second domestic hot water tank. A heat exchanger heats the water in the second tank from the fluid in the first tank which is in turn heated by being pumped through the collector.

Phase-change: A closed-loop, active system that circulates a refrigerant through the collector. When the refrigerant is heated, it vaporizes and rises to the top of the collector, where the heat is transferred to water via a heat exchanger. The refrigerant returns to a liquid state, drains to the bottom of the collector, and the process continues.

MARKETING AND DELIVERY

SMUD's solar domestic water heater program can be divided into three phases of implementation: the initial contractor-driven program during 1992, the bulk-purchase phase in 1993, and the return of the contractor-driven program in September of 1993. Marketing and delivery for each phase of the program is discussed below.

A contractor-driven implementation strategy began in May of 1992. SMUD decided to work closely with the existing solar industry to deliver systems to its customers and developed a list of contractors to participate in the program. Ten contractors participated in the 1992 program.[R#7]

The foundation for the program was laid by the completion of the SRCC's Standard OG-300. SMUD adopted OG-300 as the basis for design, durability, installation, reliability, warranties, and performance of the systems eligible for incentives in the DSM program. The District also adopted OG-300 for its inspection and quality control protocols. The utility added a training component for installers and inspectors of systems to familiarize them with the OG-300 requirements.[R#7] Forty utility energy advisors and inspectors and 18 contractors were trained.[R#13]

Incentives were designed as performance-based to reward systems that provided the largest share of hot water needs, therefore providing the largest electricity savings. SMUD also implemented a financing mechanism designed to eliminate any out-of-pocket expenses by the customer, instead internalizing them into the bill each month. The utility designed its incentives in an attempt to provide positive net cash flow (with the savings from the SDHW system outweighing the monthly payment) to the customers immediately. The average rebate was $1,200 off an average system cost of $3,600. The remaining $2,400 could be financed over a ten-year period resulting in a monthly payment of $29.20.[R#13]

With a program design in place the utility began an aggressive marketing campaign among its customers. Several brochures were produced explaining the program, solar water heating technology, and the environmental and financial benefits of participating. SMUD then promoted the program through direct mailings to all its electric water heating customers. To participate, a customer needed only to contact the utility's Energy Efficiency Department by returning a postage-paid card or calling the utility's energy hot line. Most customer contacts were generated by participating contractors.[R#13]

The utility developed a master list of contractors who had met mandated qualifications and experience requirements that was given to each interested participant. From this list, SMUD encouraged customers to solicit multiple bids for the installation of a SDHW system. The customer was then free to select a contractor from the master list and have the SDHW system installed. Typically, the approval of the loan application by the utility took two weeks, and installation of the system followed within another two weeks.[R#13]

After installation, a SMUD inspector inspected each system to ensure that it met the mandatory requirements. Under this phase of the program every installation was inspected. Any failures were remedied by the contractor at no cost and verified by another inspection.

The utility then implemented a bulk-purchasing program during 1993 in an attempt to reduce the costs associated with the technology. It has been estimated that the cost associated with SDHW systems are split in roughly equivalent thirds: 1/3 to materials, 1/3 to labor, and the final 1/3 to marketing. Given the relatively small scale of the SDHW manufacturing capability, the first two costs are difficult to reduce to a large degree.[R#8] Marketing costs remain high due to the relatively high first costs of SDHW systems, and the extremely competitive current market for SDHW systems among contractors. The utility decided to attempt to bring down marketing costs by internalizing them. SMUD believed that centralized marketing of all eligible systems would be more cost-effective than the competitive marketing that the contractors were pursuing.

A bulk-purchasing program was therefore initiated and the utility issued two Requests for Bids (RFB), the first for 195 systems and the second for 652 systems.[R#13] Both RFBs established limits for contractors and manufacturers to ensure that all were able to compete and to avoid overextending the installation or production abilities of ☞

any company while providing more experience for the utility with the various types of available systems. Each RFB specified OG-300 certified SDHW systems with a minimum three-year full system warranty and ten-year collector warranty. The bidding process was discussed and reviewed with the eligible contractors and manufacturers as well as the California Solar Energy Industries Association, all of whom endorsed the process.[R#7]

The utility's Residential Energy Services program then targeted customers with electric space and water heaters, with a goal of conducting 5,000 audits to identify potential participants. These customers were specifically targeted by the utility in an attempt to capture the largest potential energy benefits. SMUD's Home Energy Advisors then marketed the systems to these targeted customers. For an interested participant, the Energy Advisor completed the necessary paperwork and forwarded purchase orders to the contractors. A contractor then executed the final contract and installed the system.

As a result of the bulk-purchasing program, the average installed system price dropped to $2,600, a 30% savings. The utility provided rebates of an average of $850 and offered financing at 7.6% over ten years for the remaining costs, equivalent to payments each month of $19.70. Since the customer realized between $21 for a family of three and $27 for a family of four per month in energy savings, the measure had an immediate net cash flow for participants.[R#7,13] The 7.6% reflects SMUD's cost of funding at that time.[R#13] Installation and inspection procedures remained unchanged.

SMUD returned to the contractor-driven approach in September of 1993 due to the inability of the bulk-purchasing program to meet targeted participation levels. SMUD's SDHW marketing was resulting in a 50% closure rate on solar leads, but only a 15-20% rate on general energy efficiency leads, resulting in the installation of fewer systems than the utility desired. The bulk-purchase phase, bundled into a larger direct investment audit and energy improvement campaign, also suffered from a late start, beginning in May rather than January as originally planned.[R#7,13]

The current contractor-driven program will operate much the same as it did initially, however, the utility has incorporated some key lessons. To discourage artificial inflation of the price of SDHW systems a performance-based cap was instituted for rebates and financing. The maximum rebate is $863 and the financing cap is $2,087 for a total maximum incentive of $2,950. Rebates are structured with a base incentive of $550 plus $12.50 per SSR point above 40% up to a maximum SSR of 65%. The financing cap ranges from $1,669 for a system with a 40% SSR to the maximum $2,087 for a 65% SSR system.[R#13] SMUD is confident that the solar industry will be able to hold the prices at the levels established under the bidding program and reach the program's established participation targets.

MEASURES INSTALLED

Only SDHW systems are eligible in this program, although there are a number of different kinds of systems as discussed earlier. SMUD was able to install 875 systems in 1992, and has installed 600 systems to date in 1993.[R#7,13]

STAFFING REQUIREMENTS

The program is implemented by SMUD's Energy Efficiency Department. Donald E. Osborn, the senior project manager for SMUD's Solar Programs, supervises the program and is responsible for program design and implementation. Cliff Murley manages the day-to-day implementation of the SDHW program. Additionally, there are 15 personnel involved in program evaluation, including 10 individuals involved in inspecting the installations. Osborn and Murley are available to answer questions on the program. Furthermore, eight solar manufacturers and five contractors are currently participating in the program. ■

MONITORING

During the initial year of the program's implementation SMUD's trained inspectors visited every installation to confirm that the systems had been installed according to OG-300. The utility plans to inspect 20% to 50% of future installations performed by contractors that have demonstrated a satisfactory quality assurance record. SMUD also plans to re-inspect a selection of 1992 installations to perform a second evaluation and operation test.[R#13]

Additionally, SMUD is in the process of monitoring a representative set of installations. Short-term detailed field monitoring of about 20 systems will be performed by the utility with the assistance of the National Renewable Energy Laboratory (NREL). Longer-term monitoring of 200 sites has recently been implemented and will continue during 1994.[R#13]

EVALUATION

The results of the initial site inspections in combination with the second visits and utility billing data will be used to evaluate the effects of program. Customer satisfaction surveys will also be performed.

When data from the short and longer-term monitoring efforts is available, the utility will use it to verify calculated energy and demand savings, and to provide feedback to the SRCC's certification and rating process and the USH2O project.

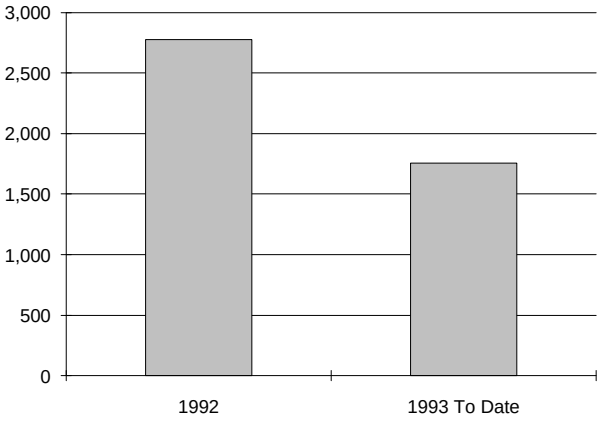
Finally, the utility is working with the solar community and the California Energy Commission to establish a SDHW Test Facility. These groups will co-fund the facility, which will be used to test current systems under real-world conditions, evaluate emerging solar technologies, and train utility personnel and others.[R#7] ■

Program Savings

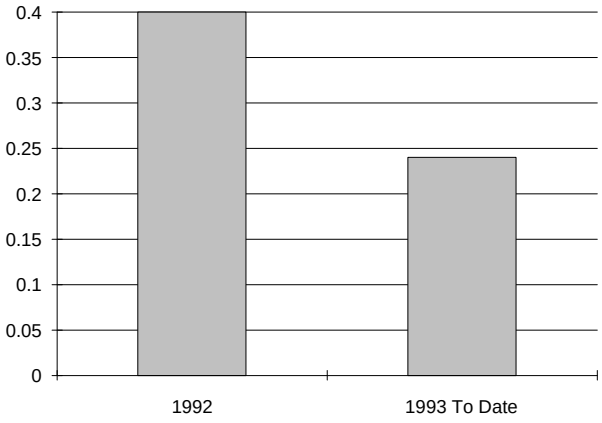
Savings Overview	*Annual Energy Savings (MWh)*	*Cumulative Energy Savings (MWh)*	*Lifecycle Energy Savings (MWh)*	*Annual Summer Capacity Savings (MW)*	*Cumulative Summer Capacity Savings (MW)*
1992	2,775	2,775	27,750	0.400	0.400
1993 To Date	1,757	4,532	17,568	0.240	0.640
Total	4,532	7,307	45,318	0.640	

Data Alert: Complete savings data exists only for 1992. Data presented in this section for 1993 is current as of October 15, 1993 but does not reflect total 1993 savings.

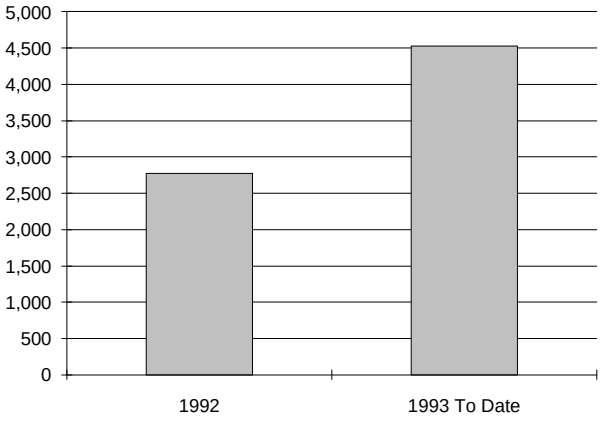
ANNUAL ENERGY SAVINGS (MWH)



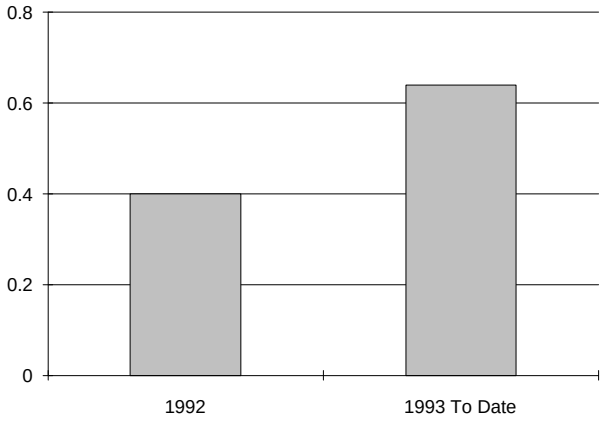
ANNUAL SUMMER CAPACITY SAVINGS (MW)



CUMULATIVE ENERGY SAVINGS (MWH)



CUMULATIVE SUMMER CAPACITY SAVINGS (MW)

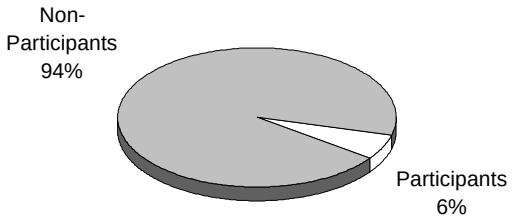


Energy savings for the program have been calculated for 1992 to be 2,775 MWh. These calculations are based on estimated hot water usage and delivery temperatures and were derived using the "TRNSYS" computer modeling tool originally supported by the Department of Energy and modified for the Solar Rating and Certification Corporation (SRCC). Hot water usage, a key variable in calculating savings, is estimated to be 20 gallons per person per day for the first two occupants, and an additional 15 gallons per person per day for each additional occupant. [R#13] The Results Center has calculated annual energy savings for 1993 to date to be 1,757 MWh based on the installation of 600 systems and SMUD's calculation of 2,928 kWh per system.

Capacity savings are estimated by SMUD based on existing measured demand data and using the SRCC computer tool. SMUD has calculated savings to be 0.4 MW for 1992, again the only year for which final data is available. These savings are average demand impacts from 1 pm to 9 pm on summer weekdays.[R#13] The Results Center has calculated capacity savings for 1993 to date to be 0.24 MW, based on the installation of 600 systems at 400 watts per system.

PARTICIPATION RATES

SMUD defines participation as an installed system. In 1992, there were 875 participants in the program, all residential.[R#7] This exceeded the program's target of 800 and represented 3% of the eligible single-family residential market. Energy savings per participant were 3.17 MWh in 1992, with an average system Solar Savings Ratio (SSR) of 65%.



Additionally, the utility has already had 600 residential systems installed during 1993 making overall program participation 6% to date. The utility has set a goal of 900 total participants for 1993 with 100 of these commercial or multi-family. SMUD has calculated the annual energy savings per participant to be 2,928 kWh in 1993.[R#7,13]

Participation	*Participants*	*Annual Energy Savings per Participant (kWh)*
1992	875	3,171
1993 To Date	600	2,928
Total	1,475	

By 2000, SMUD plans to have a total of 20,000 systems in operation. If realized, this level of participation would represent approximately 25 percent of the potential market. The utility has estimated that 30,000 single-family residential customers and another 20,000 multi-family customers could participate in the program. Additionally, the commercial and industrial market has the potential to install up to 30,000 residential-equivalent SDHW systems.[R#7,13]

FREE RIDERSHIP

Prior to the implementation of this program, the local SDHW market was installing less than ten units per year.[R#7] Therefore, SMUD does not consider free ridership to be an issue for its SDHW program at this time. If the program successfully transforms the local water heating market to the degree that solar is cost-competitive with other options absent a utility incentive, free ridership will have to be considered.

MEASURE LIFETIME

The utility has used a lifetime of ten years to make its benefit/cost and energy calculations.[R#7] However, the industry norm, supported by several reports, suggests that today's solar water heating technology meeting OG-300 standards will have a useful lifetime of 15 years or better.[R#9,10,11] Thus, the SMUD program is likely underestimating the cost-effectiveness and the potential energy and demand savings that will accrue from this program.

PROJECTED SAVINGS

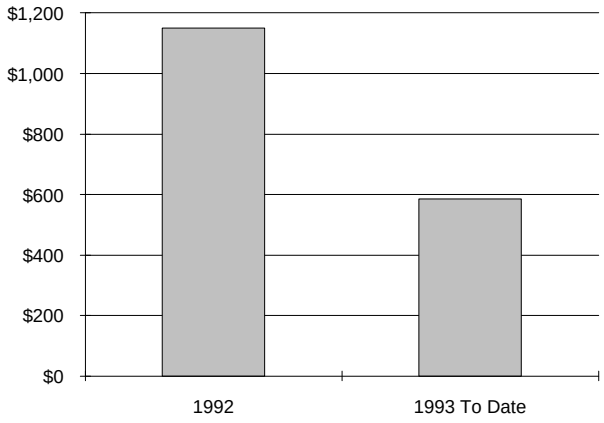
Using the ten-year useful life, SMUD has calculated that the installation of 20,000 systems by the year 2000 will provide energy savings of 48,300 MWh per year and capacity savings of 7.4 MW. These projected savings are predicated on the water usage and delivery temperature assumptions discussed above and an average household size of four people during 1992-1994 and 3.5 people thereafter.[R#7,13] ■

Cost of the Program

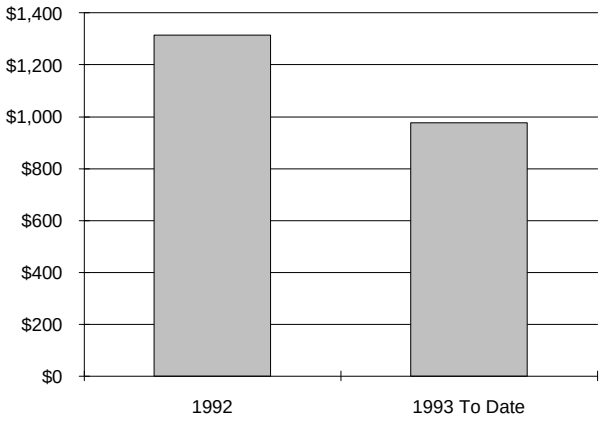
Costs Overview	*Direct Staff Labor (x1000)*	*Marketing (x1000)*	*Contract Services Support (x1000)*	*Quality Assurance Support (x1000)*	*Rebates (x1000)*	*Overhead (x1000)*	*Total Program Cost (x1000)*	*Cost per Participant*
1992	$44.4	$52.8	$18.4	$21.8	$1,002.5	$10.1	$1,150.0	$1,314.26
1993 To Date	$31.8	$37.8	$13.2	$15.6	$480.0	$7.2	$585.6	$976.00
Total	$76.2	$90.6	$31.6	$37.4	$1,482.5	$17.3	$1,735.6	

Data Alert: Complete cost data exist only for 1992. Data presented in this section for 1993 is current as of October 15, 1993 but does not reflect total 1993 costs. The 1993 costs have not been levelized as the yearly conversion factor is not yet available.

TOTAL PROGRAM COST (x1,000)



COST PER PARTICIPANT



Cost of Saved Energy (¢/kWh)	*Discount Rates*						
	3%	4%	5%	6%	7%	8%	9%
1992	4.86	5.11	5.37	5.63	5.90	6.18	6.46
1993 To Date	3.91	4.11	4.32	4.53	4.75	4.97	5.19

SMUD has calculated its costs for the SDHW program on a per system basis. By spending an average of $1,314 per system for 875 systems, the utility totalled expenditures of $1,150,000 in 1992. Expenditures to date in 1993 total $585,600 on 600 systems, for a grand total of $1,735,600.

COST EFFECTIVENESS

SMUD has calculated the cost of its SDHW program in comparison with the avoided cost of supplying electricity generated by gas turbine. Each calculation assumes a ten-year capitalization period. In comparison with the utility's avoided cost of $989 per system, the SDHW program is expected to have a 1.01 benefit/cost ratio in 1993 based on a limited ten-year lifetime. Using a fifteen-year system lifetime, the ratio improves to 1.51. This ratio is expected to improve to 1.33 (or 2.0 for the fifteen-year calculation) over the next four years as a greater number of systems are installed at a lower unit cost.[R#7,13]

Using a 5% real discount rate The Results Center calculated the cost of saved energy for the 1992 program to be 5.37 ¢/kWh. This cost has decreased during 1993 to 4.32 ¢/kWh.

COST PER PARTICIPANT

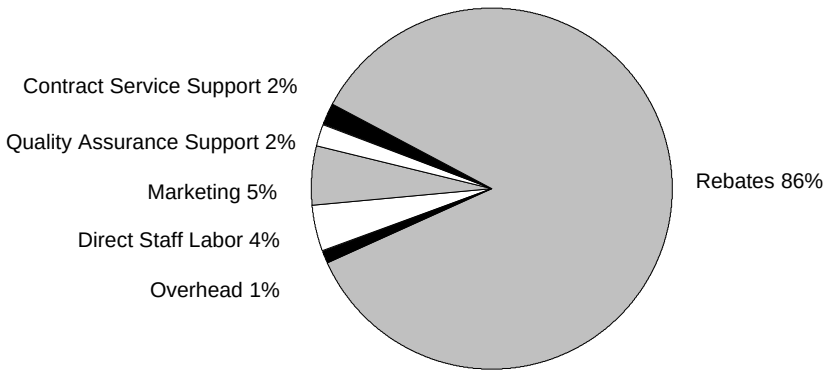
For each of the 875 participants in 1992, the utility spent an average of $1,314. Costs have decreased in 1993 to $976 for each installed system.[R#13] This cost is likely to continue to decrease in future years as the number of participants increases and the unit cost of systems decreases. Given the large effect of rebates on the per participant cost, the financing cap implemented in 1993 is likely to substantially contribute to further cost reduction.

The customer has the option to bear no up-front costs in this program by accepting SMUD financing and making a monthly payment. However, the utility has attempted to set incentive levels such that the energy savings are greater than the monthly charge, resulting in an immediate net-positive cash flow for the customer.

COST COMPONENTS

SMUD has disaggregated its SDHW program cost components into six major categories on a per system basis. Five of these costs have remained fixed over the program's life, while the rebate level has decreased dramatically from $1,146 in 1992 to $800 in 1993. The average costs of the remaining components in 1993 dollars are marketing ($63), fully-burdened staff labor ($53), quality assurance support ($26), contract service support ($22), and overhead ($12).[R#13] To calculate aggregate costs for each of these components as shown in the attached table, The Results Center multiplied the average cost by the total number of installed systems each year.

In 1993, the targeted level of incentives, including both rebates and loan funding, totals $2,400,000 (unlevelized) for the expected installation of 900 systems.[R#13] ■



Environmental Benefit Statement

AVOIDED EMISSIONS: Based on 7,307,000 kWh saved 1992 - Present

Marginal Power Plant	*Heat Rate BTU/kWh*	*% Sulfur in Fuel*	*CO2 (lbs)*	*SO2 (lbs)*	*NOx (lbs)*	*TSP* (lbs)*
Coal	**Uncontrolled Emissions**					
A	9,400	2.50%	15,754,000	374,000	76,000	8,000
B	10,000	1.20%	16,799,000	145,000	49,000	36,000
	Controlled Emissions					
A	9,400	2.50%	15,754,000	37,000	76,000	1,000
B	10,000	1.20%	16,799,000	14,000	49,000	2,000
C	10,000		16,799,000	96,000	48,000	2,000
	Atmospheric Fluidized Bed Combustion					
A	10,000	1.10%	16,799,000	44,000	24,000	12,000
B	9,400	2.50%	15,754,000	37,000	30,000	2,000
	Integrated Gasification Combined Cycle					
A	10,000	0.45%	16,799,000	30,000	5,000	12,000
B	9,010		15,111,000	11,000	4,000	1,000
Gas	**Steam**					
A	10,400		9,163,000	0	21,000	0
B	9,224		7,957,000	0	50,000	2,000
	Combined Cycle					
1. Existing	9,000		7,957,000	0	31,000	0
2. NSPS*	9,000		7,957,000	0	14,000	0
3. BACT*	9,000		7,957,000	0	2,000	0
Oil	**Steam--#6 Oil**					
A	9,840	2.00%	13,262,000	201,000	24,000	23,000
B	10,400	2.20%	14,066,000	199,000	30,000	14,000
C	10,400	1.00%	14,066,000	28,000	24,000	8,000
D	10,400	0.50%	14,066,000	84,000	30,000	5,000
	Combustion Turbine					
#2 Diesel	13,600	0.30%	17,603,000	35,000	54,000	3,000
Refuse Derived Fuel						
Conventional	15,000	0.20%	20,898,000	54,000	71,000	16,000

In addition to the traditional costs and benefits there are several hidden environmental costs of electricity use that are incurred when one considers the whole system of electrical generation from the mine-mouth to the wall outlet. These costs, which to date have been considered externalities, are real and have profound long term effects and are borne by society as a whole. Some environmental costs are beginning to be factored into utility resource planning. Because energy efficiency programs present the opportunity for utilities to avoid environmental damages, environmental considerations can be considered a benefit in addition to the direct dollar savings to customers from reduced electricity use.

The environmental benefits of energy efficiency programs can include avoided pollution of the air, the land, and the water. Because of immediate concerns about urban air quality, acid deposition, and global warming, the first step in calculating the environmental benefit of a particular DSM program focuses on avoided air pollution. Within this domain we have limited our presentation to the emission of carbon dioxide, sulfur dioxide, nitrous oxides, and particulates. (Dollar values for environmental benefits are not presented given the variety of values currently being used in various states.)

HOW TO USE THE TABLE

1. The purpose of the accomanying page is to allow any user of this profile to apply SMUD's level of avoided emissions saved through its Solar Domestic Hot Water Heating program to a particular situation. Simply move down the left-hand column to your marginal power plant type, and then read across the page to determine the values for avoided emissions that you will accrue should you implement this DSM program. Note that several generic power plants (labelled A, B, C,...) are presented which reflect differences in heat rate and fuel sulfur content.

2. All of the values for avoided emissions presented in both tables include a 10% credit for DSM savings to reflect the avoided transmission and distribution losses associated with supply-side resources.

3. Various forms of power generation create specific pollutants. Coal-fired generation, for example, creates bottom ash (a solid waste issue) and methane, while garbage-burning plants release toxic airborne emissions including dioxin and furans and solid wastes which contain an array of heavy metals. We recommend that when calculating the environmental benefit for a particular program that credit is taken for the air pollutants listed below, plus air pollutants unique to a form of marginal generation, plus key land and water pollutants for a particular form of marginal power generation.

4. All the values presented represent approximations and were drawn largely from "The Environmental Costs of Electricity" (Ottinger et al, Oceana Publications, 1990). The coefficients used in the formulas that determine the values in the tables presented are drawn from a variety of government and independent sources. ■

*** Acronyms used in the table**

TSP = Total Suspended Particulates
NSPS = New Source Performance Standards
BACT = Best Available Control Technology

LESSONS LEARNED

SMUD has learned several specific implementation lessons over the course of the SDHW program. First, the utility stresses the importance of training for both utility personnel and contractors on the performance, installation and inspection of SDHW systems. The need for effective training is notable particularly on OG-300 requirements but also for general program requirements. A high level of training is essential if the quality control necessary to ensure the program's success is to be instituted and maintained.[R#13]

Second, establishing the correct incentives at the correct level is crucial. SMUD has stressed performance-based incentives that increase with the energy and capacity benefits of a system rather than reflecting the system cost. These performance-based incentives encourage consumers and contractors to buy and sell more efficient products.[R#13]

SMUD has also adjusted its rebate levels during the program in an attempt to find the proper range. The utility believes that the 1992 rebates in particular were overly generous. However, the adoption of a financing cap for 1993 appears to have resolved the incentive question.[R#13]

Another lesson comes from the bulk purchasing program. SMUD realized that its marketing was simply not resulting in the desired rate of implementation. Rather than opting to continue this phase of the program the utility determined it would be more effective to return to a contractor-driven effort. However, utilities with larger electric water heating markets may be best served by such a program rather than a naturally inflationary rebate and loan program as the centralized purchase of SDHW systems could provide substantial cost savings.[R#13]

The SDHW program has achieved some success of note from the perspective of both the utility and the market. First, the program has provided the District with savings, particularly important cost-effective capacity savings. Second, the program has raised the awareness of solar as a viable water heating option in the utility's service territory. SMUD has placed substantial emphasis on targeting a market for this technology and working with its customers to ensure their needs are met. Using environmental benefits as a motivation has proven to be a valuable marketing tool. Finally, the program has resulted in significant price reductions of SDHW systems. This last result is noteworthy given that the high first cost of the systems has been recognized as a primary barrier to their adoption. By raising interest and lowering cost, the utility has begun to transform the local market for SDHW systems.

However, this local success is not to be extrapolated to a larger market. The SMUD program installed less than 900 systems in 1992 and has targeted that many for 1993. These sales, while impressive in a local market that was supporting less than ten systems prior to the program, do not translate to a major market transformation. If the utility succeeds in stimulating the installation of 20,000 systems by the year 2000, it would certainly have market effects beyond SMUD's service territory.

To its credit, the utility has recognized the need to improve the market for SDHW systems beyond its service territory. Its efforts in the USH2O collaborative are aimed at ensuring a broad market transformation. Such a transformation should have substantial benefits for SMUD primarily through an increased manufacturing and installation capability within the SDHW industry and correspondingly lower unit costs for the technology. SMUD's program goals are in fact predicated on an anticipated long-term reduction in price for SDHW systems as the result of a sustained market improvement.[R#13]

In many ways the SMUD program is looked upon as the demonstration model for utility SDHW initiatives. Given the lack of a tested program to emulate, the SMUD program has gone through a number of changes as it has been implemented. The most significant change was the shift from a contractor-driven program to a bulk-purchas-

ing program and back. The motivation for these changes was the need to meet installation targets and to avoid serious disruption of the local solar industry.

Having already demonstrated the flexibility to adapt and modify the program, it seems likely that the utility will continue to do so to move the substantial volumes of systems that program plans specify. SMUD feels that SDHW systems are a viable demand-side option, but the utility must deliver enough systems to make substantial energy impacts and lower system costs.

TRANSFERABILITY

SMUD has clearly developed expertise working with SDHW systems and the solar industry as a whole. Any other utility seeking to implement a program with stated goals of the magnitude of the SMUD program is likely to face very real information and cost barriers. However, progress by the USH2O collaborative may obviate these barriers by providing the necessary information to design and evaluate a DSM program. The continued involvement of the solar industry, particularly through the widespread adoption of SRCC Standard OG-300, can provide utilities with reliable performance guarantees. A broad market transformation, as discussed above, stimulated by USH2O, will address the system cost barrier and ease program implementation.

A candidate utility will likely still be faced with local barriers, including system availability and customer knowledge. Such a utility will then need to inform its customers about SDHW as a water heating option, ensure their understanding of the benefits (notably the environmental advantages), and overcome any negative perception that formed as a result of experience during the tax credit years.

However, SMUD feels that the available SDHW technology that meets OG-300 requirements is completely reliable and can provide real energy and capacity savings to other utilities. A utility that learns from the experiences at SMUD and benefits from USH2O should be able to avoid small and costly demonstration programs and implement a successful full-scale program.

Finally, any utility considering such a program must first perform a detailed assessment of the electric hot water heating load in its service territory. The higher the saturation of electric hot water heaters, the greater the potential for savings from such a program. Inversely, if a service territory is characterized by a concentration of gas-fired hot water heaters, a solar program will have to be tailored accordingly, either in conjunction with the gas utility (if the electric utility doesn't provide gas services – the case in Sacramento) or as a program aimed at a limited number of conversion possibilities. ■

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Special thanks to Don Osborn for his guidance and support throughout the development of this profile.